

## SCANNING MODULE

BACKGROUND OF THE INVENTIONField of the Invention

The present invention relates to a scanning module for reading a document image and outputting an electric  
5 signal representative of the document image and more particularly to a miniature, simple scanning module whose optical path length is easily adjustable.

Description of the Background Art

10 It is a common practice with a copier or similar image forming apparatus to use a scanning system of the type including a stationary line sensor and two carriages that move at full speed and half speed, respectively. This type of scanning system, conventional with an analog scanner,  
15 is not always desirable when it comes to the miniaturization and the reduction of production cost of a scanner.

A current trend in the imaging art is toward a scanner in which a line sensor, a lens, a lamp and so forth are  
20 constructed into a single movable scanning module in order

to reduce production cost. The prerequisite with this type of scanner is that to focus imagewise reflection from a document on the line sensor in a preselected magnification, an optical path extending from the document to the line sensor be provided with a preselected length. This gives rise to a problem that the scanning module is bulky when provided with the preselected optical path length. While the scanning module may be reduced in size by use of a miniature lens having small optical path length, such a lens aggravates aberration and therefore prevents a beam from a document from being focused on the line sensor, resulting in low image quality.

In light of the above, it has been proposed to reduce the size of a scanning module by folding an optical path with, e.g., mirrors. Japanese Patent Laid-Open Publication No. 2001-174932, for example, discloses an image scanner including one or more multiple-reflection mirrors that reflect a beam from a document a plurality of times, so that necessary optical path length is implemented by a small number of mirrors (Prior Art 1 hereinafter).

Japanese Patent Laid-Open Publication No. 3-10564 teaches an image scanner including a transparent member configured to bend light incident from a document a plurality of times (Prior Art 2 hereinafter). Prior Art

2 implements necessary optical path length while reducing space necessary for reflected light.

Further, Japanese Patent Laid-Open Publication Nos. 7-170376 (Prior Art 3 hereinafter) and 9-163098 proposes  
5 an optical unit (Prior Art 4 hereinafter) each propose an optical unit including a pair of mirrors configured to reflect light incident from a document a plurality of times. Prior Arts 3 and 4 each contemplate to reduce the size of an optical unit while guaranteeing required optical path  
10 length.

Generally, scanners with reduction optical systems must be individually adjusted in optical path length between a focus on a document and a line sensor in order to accurately establish a designed optical magnification.

15 Prior Arts 1 through 4 described above have the following problems unsolved although contemplating to guarantee optical path length and reduce module size at the same time.

Prior Art 1 has a problem that optical path length  
20 cannot be adjusted unless a plurality of mirrors, including the multiple-reflection mirrors, are adjusted in position one by one, resulting in sophisticated adjustment. Further, in Prior Art 1, the distance between the mirror to which a beam from a document is incident first  
25 and a glass platen is selected to be smaller than the

vertical distance between the optical axis of a lens and the glass platen. On the other hand, to accommodate great optical path length, the optical path between the document and the mirror to which the beam from the document is incident first should preferably have great length. In this respect, the structure taught in Prior Art 1 is not adequate from the size reduction standpoint.

As for Prior Art 2, it is likely that incident light or reflected light is refracted at the interface between the transparent member and the air due to a difference in refractive index. To obviate such refraction, light must be input to and output from the above interface perpendicularly to the interface. Therefore, when the position of the transparent member is varied, the mirrors, lens and image sensor must also be adjusted in position, resulting in sophisticated adjustment of optical path length. Further, because the transparent member bends incident light a plurality of times to thereby fold the optical path, it is difficult to reduce the size of the mirror to which light from a document is incident first and the size of the transparent member. This configuration is therefore not adequate from the size reduction standpoint.

Prior Art 3 does not allow optical path length to be easily adjusted because all the mirrors, including the

pair of mirrors, must be individually varied in position. Moreover, light propagated through the lens crosses the optical path between the pair of mirrors, so that the pair of mirrors must be enclosed by a case capable of intercepting extraneous light, obstructing size and cost reduction of the module.

Prior Art 4 has the same problem as Prior Art 3 as to the adjustment of optical path length stated above. In addition, Prior Art 4 has another problem that the lens, having a small focal distance and used to reduce module size, needs high accuracy, obstructing cost reduction of the module.

As for the scanning system using a stationary line sensor and a full-speed and a half-speed carriage, as stated earlier, Japanese Patent Laid-Open Publication No. 11-146131 discloses an image scanner and an image forming apparatus configured to adjust optical path length by shifting only a mirror that reflects light toward reading means (Prior Art 5 hereinafter). However, Prior Art 5 is not applicable to a scanner of the type having a line sensor, lens, lamp and so forth constructed into a single movable module. Further, Prior Art 5 adjusts optical path length by moving a second mirror, which is originally movable in the scanning direction, i.e., without using any exclusive member for the adjustment. That is, Prior Art 5 simply

controls the movement of the half-speed carriage in the conventional scanner.

Japanese Patent Laid-Open Publication No. 7-56242 teaches an image scanning unit of the type folding an optical path by reflecting light from a document with, e.g., mirrors (Prior Art 6 hereinafter). To facilitate the adjustment of optical path length, Prior Art 6 uses a lens and an image pickup section constructed integrally with each other and movable along an optical path. This, according to the above document, allows magnification to be easily adjusted.

Prior Art 6, however, needs an exclusive mechanism for moving only the lens along the optical axis and an exclusive mechanism for moving a lens unit, including the lens and image pickup section, along the optical axis. Further, Prior Art 6 needs a mechanism for affixing the lens and lens unit at desired positions. A module with such mechanisms is sophisticated in structure and cannot be reduced in size. Moreover, the adjustment of optical path length effected by moving the lens and image pickup section together needs a large margin for adjustment because the amount of displacement and the amount of variation of optical path length are equal to each other.

As stated above, as for a scanning system of the type including a line sensor, a lens, a lamp and so forth

constructed into a single movable module, none of Prior Arts 1 through 6 realizes a simple, compact module allowing its optical path length to be easily adjusted.

5     SUMMARY OF THE INVENTION

It is an object of the present invention to provide a simple, miniature scanning module allowing its optical path length to be easily adjusted.

10     A scanning module of the present invention includes a light source for illuminating a document. A pair of mirrors consist of a first mirror to which light reflected by the document is incident and a second mirror positioned substantially parallel to and spaced by a preselected distance from the first mirror. The pair of mirrors  
15     reflects the light a plurality of times therebetween and then output it as light reflected from the first mirror. A third mirror reflects the reflected light from the pair of mirror away from the pair of mirrors in substantially parallel to the document. A fourth mirror reflects the  
20     light incident from the third mirror toward a lens in a direction substantially opposite to a direction in which it is reflected from the pair of mirrors to the third mirror. A fifth mirror reflects the light incident from the lens in a direction substantially opposite to a direction in  
25     which it is reflected from the third mirror to the fourth

mirror. A linear sensor is spaced from the fifth mirror by a preselected distance such that the light passed through the lens is focused on the linear sensor. The pair of mirrors are adjustable in position on a path, extending  
5 from the document to the first mirror, while maintaining a positional relation therebetween.

If desired, the pair of mirrors, reflected the light a plurality of times therebetween, may output it as light reflected from the second mirror  
10

#### BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description taken with the  
15 accompanying drawings in which:

FIG. 1 is a view showing a first embodiment of the scanning module in accordance with the present invention;

FIG. 2 is an external isometric view of the illustrative embodiment;

20 FIG. 3 is a view showing a parallel mirror unit included in the illustrative embodiment;

FIG. 4 is a view showing the parallel mirror unit mounted on a frame also included in the illustrative embodiment;

25 FIG. 5 is a view showing a sensor unit further



included in the illustrative embodiment;

FIG. 6 is a view demonstrating the adjustment of optical path length unique to the illustrative embodiment;

FIG. 7 is a view showing a second embodiment of the present invention; and

FIG. 8 is a view showing a third embodiment of the present invention.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. 1 and 2 of the drawings, a first embodiment of the scanning module in accordance with the present invention is shown. As shown, the scanning module is generally made up of a linear sensor 1, a package or circuit board 1', a lens 2, a frame 4, a light source 5, and mirrors 11, 12, 13, 14 and 15.

The linear sensor 1 has a plurality of photoelectric transducing devices, which convert incident light to a corresponding electric signal, arranged in an array although not shown specifically. When the light source 5 illuminates a document 20, the resulting imagewise reflection from the document 20 is focused on the linear sensor 1 via the lens 2 and mirrors 11 through 15. The lens 2 and other devices are mounted on the package 1' while the mirrors 11 and 12 are mounted on and positioned by the frame 4.

As shown in FIG. 3, the mirrors 11 and 12 are supported by opposite side walls 3a and 3b substantially in parallel to each other with mirror faces thereof facing each other. Let the unit constituted by the side walls 3a and 3b and mirrors 11 and 12 be referred to as a parallel mirror unit. The side walls 3a and 3b are respectively formed with slots 30a and 30b elongate in the direction perpendicular to the mirror surfaces of the mirrors 11 and 12.

As shown in FIG. 4, the parallel mirror unit is fastened to the frame 4 by screws passed through the slots 30a and 30b. In this configuration, the position where the parallel mirror unit is mounted on the frame 4 is adjustable in the lengthwise direction of the slots 30a and 30b, as indicated by arrows Aa and Ab in FIGS. 3 and 4.

As shown in FIG. 5, the package 1', lens 2 and mirrors 13, 14 and 15 are mounted on a frame 6 although the mirror 15, positioned at the rear of the frame 6, is not visible. The unit made up of the package 1', lens 2, frame 6 and mirrors 13 through 15 will be referred to as a sensor unit hereinafter. The sensor unit is affixed to the frame 4 at a preselected position and therefore connected to the parallel mirror unit via the frame 4.

Referring again to FIG. 1, light, issuing from the

light source 5 and reflected from a focus X on the document 20, is input to the parallel mirror unit, which includes the mirrors 11 and 12 substantially parallel to the document 20 and to each other. In the parallel mirror unit, 5 the light is repeatedly reflected by the mirrors 11 and 12 a plurality of times and then reflected by the mirror 11 toward the mirror 13.

The light incident to the mirror 13 is reflected thereby toward the mirror 14 in substantially parallel to 10 the document 20 away from the parallel mirror unit. The light is then reflected by the mirror 14 in the direction substantially opposite to the direction in which it is reflected toward the mirror 13, i.e., substantially in the direction in which it is propagated from the focus X to 15 the mirror 11.

The light reflected by the mirror 14 is incident to the mirror 15 via the lens 2 and reflected by the mirror 15 toward the linear sensor 1 in the direction 20 substantially opposite to the direction in which it is reflected from the mirror 13 to the mirror 14. The linear sensor 1 outputs an electric signal corresponding to the light incident thereto, thereby reading an image carried on the document.

The mirror 15 reflects the light incident thereto 25 via the lens 2 toward the parallel mirror unit, as stated

above. It is therefore possible to effectively use a limited space available in the scanning module for thereby reducing the size of the module.

How the illustrative embodiment allows the length  
5 of the optical path, extending from the document 2 to the line sensor 1, to be adjusted will be described hereinafter. To implement a designed optical magnification, it is necessary to adjust the length of the above optical path to preselected length.

10 The illustrative embodiment allows the length of the optical path to be adjusted by varying the position where the parallel mirror unit is mounted on the frame 4. More specifically, as shown in FIG. 6, the parallel mirror unit is slidable relative to the frame 4 in parallel to the  
15 optical path extending from the document 20 to the mirror 11, as indicated by an arrow. The length of the optical path increase when the parallel mirror unit is slid away from the document 20 or decreases when the former is slid toward the latter. At this instant, the mirrors 11 and  
20 12 remain parallel to each other during such movement and therefore do not have to be readjusted in position individually.

Further, when the parallel mirror unit is moved, as stated above, the distance between the mirror 11 and the  
25 document and the distance between the mirrors 11 and 13

vary at the same time. Therefore, the ratio of the amount of displacement of the parallel mirror unit to the amount of variation of optical path length is substantially 1 : 2. Stated another way, the length of the optical path  
5 varies by an amount substantially two times as large as the amount of displacement of the parallel mirror unit. This allows a margin for the adjustment of the above length and therefore the overall size of the scanning module to be reduced.

10 Moreover, members, including a lens, are absent on the extension of the optical path extending from the document 20 to the mirror 11 on which the reflection is incident first. It is therefore possible to provide the above optical path with the maximum length allowable in  
15 relation to the dimensions of the scanning module. It follows that the light reflected from the document 20 is more reduced in size before reaching the mirror 11, allowing the mirror 11, among others, to be reduced in size.

As stated above, the scanning module of the  
20 illustrative embodiment implements easy adjustment of optical path length and has a miniature configuration.

FIG. 7 shows a second embodiment of the scanning module in accordance with the present invention. Because the second embodiment to be described hereinafter is  
25 generally similar to the first embodiment, identical

structural elements are designated by identical reference numerals and will not be described specifically in order to avoid redundancy.

5 The mirrors 11 and 12 shown in FIG. 7 are supported by the side walls 3a and 3b, FIG. 3, in exactly the same manner as in the first embodiment, constituting the parallel mirror unit. Also, the parallel mirror unit is fastened to the frame 4 by screws via the slots 30a and 30b, FIG. 3, formed in the side walls 3a and 3b. The sensor unit is affixed to the frame 4 as in the first embodiment and therefore connected to the parallel mirror unit via the frame 4.

15 As shown in FIG. 7, in the illustrative embodiment, the parallel mirror unit and sensor unit are connected to each other in the direction opposite to the direction shown in FIG. 2. More specifically, in the external view shown in FIG. 2, only the sensor unit of the illustrative embodiment is inverted in the up-and-down direction.

20 In operation, the light, reflected from the focus X on the document 20, is input to the parallel mirror unit, which includes the mirrors 11 and 12, and then repeatedly reflected by the mirrors 11 and 12 a plurality of time in the same manner as in the first embodiment. Subsequently, the light is reflected by the mirror 12 toward the mirror 25 13.

The light incident to the mirror 13 is reflected thereby toward the mirror 14 in substantially parallel to the document 20 away from the parallel mirror unit. The light is then reflected by the mirror 14 in the direction  
5 substantially opposite to the direction in which it is reflected toward the mirror 13, i.e., substantially in the direction in which it is propagated from the focus X to the mirror 11.

The light reflected by the mirror 14 is incident to  
10 the mirror 15 via the lens 2 and reflected by the mirror 15 toward the linear sensor 1 in the direction substantially opposite to the direction in which it is reflected from the mirror 13 to the mirror 14. The linear sensor 1 outputs an electric signal corresponding to the  
15 light incident thereto, thereby reading the image of the document.

The illustrative embodiment allows optical path length to be adjusted in exactly the same manner as the previous embodiment and therefore achieves the same  
20 advantages as the first embodiment.

FIG. 8 shows a third embodiment of the scanning module in accordance with the present invention. Because the third embodiment is also generally similar to the first embodiment, identical structural elements are designated  
25 by identical reference numerals and will not be described

specifically in order to avoid redundancy. Let the following description concentrate on differences between the first and third embodiments.

As shown in FIG. 8, in the illustrative embodiment,  
5 the mirrors 11 and 12 are not parallel to each other, but are inclined such that the distance therebetween is greater at one side where the reflection from the document 20 is incident, i.e., the side close to the package 1' than the other side. Also, the mirrors 11 and 12 are parallel  
10 to the document 20 in the lengthwise direction, but are inclined by a preselected angle relative to the document 20 in the widthwise direction.

The operation of the illustrative embodiment is identical with the operation of the first embodiment  
15 except for the following. Although the light reflected from the document 20 is incident to the parallel mirror unit including the mirrors 11 and 12 as in the first embodiment, the light is turned back while being repeatedly reflected by the mirrors 11 and 12 because the  
20 mirrors 11 and 12 are inclined, as stated earlier. As a result, the light is reflected from the side where it is incident to the mirror 11 toward the mirror 13. This is followed by the same optical path as in the first embodiment.

25 The illustrative embodiment also achieves the same



advantages as the first embodiment. Further, in the illustrative embodiment, the parallel mirror unit is configured such that the light incident thereto is repeatedly reflected between the mirrors 11 and 12 and  
5 again output from the incidence side. Stated another way, the mirrors 11 and 12 are inclined such that the light incident to the parallel mirror unit is turned back to the incidence side. This configuration is successful to increase the number of times of reflection in the parallel  
10 mirror unit and therefore to reduce the size of the individual member included in the sensor unit.

It is to be noted that the number of times of reflection between the mirrors 11 and 12 shown and described in the illustrative embodiments is only  
15 illustrative, but not restrictive. Also, the configuration of the individual member shown and described is only illustrative. For example, while the slots 30a shown in FIG. 3 are formed in a projection protruding from the side wall 3a substantially perpendicularly thereto,  
20 the slots 30a may, of course, be positioned in substantially the same plane as the side wall 3a. This is also true with the slots 30b formed in the other side wall 3b. Further, the parallel mirror unit may be directly connected to the frame 6 without the intermediary of the  
25 frame 4.

In summary, it will be seen that the present invention provides a scanning module having various unprecedented advantages, as enumerated below.

(1) The scanning module is small size because light  
5 is reflected between a pair of mirrors a plurality of times.

(2) The pair of mirrors can be adjusted in position without their positional relation disturbed, allowing the length of an optical path to be easily varied.

(3) An optical path, extending from the pair of  
10 mirrors, is folded in the form of a Japanese character "〇" or an alphabet "G", further reducing the size of the scanning module.

(4) Only the pair of mirrors are fixed in position by an exclusive member independently of the other mirrors,  
15 so that the mirrors around a lens, i.e., other than the pair of mirrors can be fixed in position by another member. It follows that the mirrors around the lens to which the light, repeatedly reflected by the pair of mirrors, is incident can be made smaller in size than the pair of  
20 mirrors, contributing to the cost reduction of the scanning module. In addition, such mirrors around the lens save space and allow, e.g., an electronic circuit board to be arranged in the resulting unoccupied space.

Various modifications will become possible for  
25 those skilled in the art after receiving the teachings of

the present disclosure without departing from the scope thereof.